DECEMBER, 1926 BULLETIN 252

VIRGINIA POLYTECHNIC INSTITUTE
VIRGINIA AGRICULTURAL EXPERIMENT STATION

In such tests the yields and resistance to anthracnose of red clover from different sources are discovered.

RED CLOVER EXPERIMENTS

By

T. K. WOLFE AND M. S. KIPPS

BLACKSBURG, MONTGOMERY COUNTY, VIRGINIA

VIRGINIA AGRICULTURAL EXPERIMENT STATION

BOARD OF CONTROL

THE EXECUTIVE COMMITTEE OF THE BOARD OF VISITORS OF THE VIRGINIA POLYTECHNIC INSTITUTE.

ROBT. S. MOSS, *Chairman* ---------- Burkes Garden, Tazewell County
T. GILBERT WOOD ---------- Roanoke, Roanoke County
JAS. P. WOODS ---------- Roanoke, Roanoke County
T. JUDSON WRIGHT ---------- Norfolk, Norfolk County
J. A. BURRUSS, *ex officio* ---------- Blacksburg, Montgomery County

ADMINISTRATIVE OFFICERS

J. A. BURRUSS, A.M., Ph.D. ---------- President
A. W. DRINKARD, JR., Ph.D. ---------- Director

STAFF OF THE DEPARTMENT OF AGRONOMY

T. B. HUTCHESON, M.S. ---- Agronomist and Supervisor of County Exp. Stations
T. K. WOLFE, Ph.D. ---------- Agronomist
M. S. KIPPS, M.S. ---------- Assistant Agronomist
W. W. GREEN, (Bowling Green) ---------- Superintendent Caroline Station
B. G. ANDERSON, B.S., (Appomattox) ---- Superintendent Appomattox Station
R. P. COCKE, (Williamsburg) ---------- Superintendent James City Station
E. T. BATTEN, B.S., (Holland) ---------- Superintendent Nansemond Station
T. L. COPLEY, B.S., (Chatham) ---------- Superintendent Pittsylvania Station
P. T. GISH, B.S., (Fishersville) ---------- Superintendent Augusta Station
H. C. MARSHALL, (Charlotte C. H.) ---------- Superintendent Charlotte Station
O. P. STRAWN, (Martinsville) ---------- Superintendent Henry Station

CONTENTS

RED CLOVER EXPERIMENTS

By T. K. Wolfe and M. S. Kipps

Red clover is the leading legume used for forage purposes in Virginia. Not only is red clover of importance from the standpoint of the production of feed for livestock, but also its value for soil improvement has long been appreciated. Unfortunately the production of red clover on most farms has become increasingly difficult and on many farms good crops of red clover have not been obtained for many years. An important factor in the decrease in productivity of much of the land in Virginia is the inability of farmers to secure good crops of red clover.

For a number of years much attention has been given to selection and use of the proper varieties of crops, such as corn, wheat, oats, and barley, but as a general rule little attention has been paid to the development and use of different types of red clover and other forage crops. In the case of corn much attention has been given to securing seed corn from localities where the climatic conditions are similar to those under which the seed is to be planted. Results show that climate has a marked effect on corn, especially in the development of types which vary in time of maturity. Recent experimental tests show that the temperature of the soil is a very important factor in determining whether certain plant diseases will develop when crops known ordinarily to be susceptible are grown. Tests conducted by the United States Department of Agriculture and by this Experiment Station show that red clover seed from different sources vary in its yielding ability and resistance to disease when planted in Virginia. The results secured emphasize the point that if best returns are to be obtained in Virginia, great care should be exercised in selecting red clover seed from the proper source.

The experiments with red clover discussed in this bulletin were conducted in cooperation with the Office of Forage-Crop Investigations, Bureau of Plant Industry, United States Department of Agriculture. Several people have rendered valuable assistance in connection with these experiments. Dr. A. J. Pieters and Mr. L. W. Kephart of the Office of Forage-Crop Investigations made arrangements for supplying the seed and made many helpful suggestions. Dr. S. A. Wingard of the Department of Plant Pathology of this Experiment

Edition of 15,000 copies.

Station made most of the observations in reference to anthracnose infection. Mr. J. G. Godkin, Plant Pathologist of the Virginia Agricultural Extension Division, Dr. John Monteith, Jr., of the Office of Vegetable and Forage Diseases, Bureau of Plant Industry, United States Department of Agriculture, and Dr. F. D. Fromme, Plant Pathologist of this Experiment Station, were of great assistance in making observations on anthracnose infection. The authors wish to take this opportunity to thank all of these gentlemen for the assistance they have rendered.

Anthracnose as a Cause of Red Clover Failure

Farmers have known for a long time the importance of lime, fertilizers, proper methods of seedbed preparation and seeding, inoculation, good drainage, and an abundant supply of soil organic matter in securing luxuriant crops of clover. The part that disease plays in red clover production is not so well known and appreciated by farmers. Tests and observations in Virginia and other places show that, when the soil and climatic conditions are favorable, good stands of clover are not secured regularly. At least in some instances the presence of disease is the cause of failure.

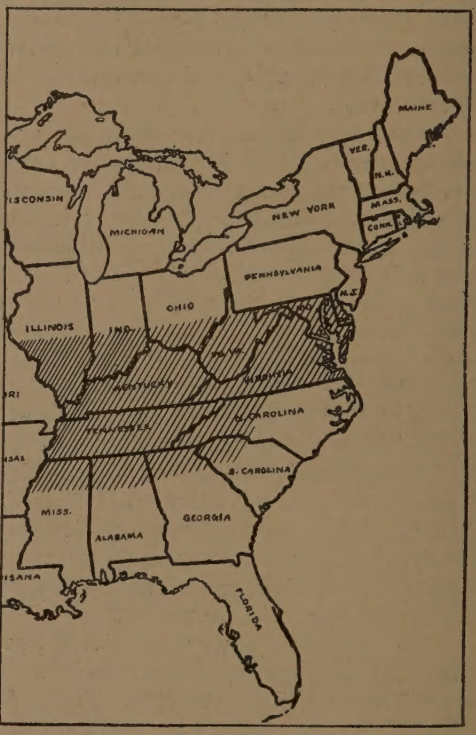

FIG. 1.—Map of the eastern portion of the United States, showing the distribution of severe anthracnose trouble. Anthracnose is severe in all the shaded area, and a great deal of loss from the disease probably occurs also in the territory north and west of this area, but exact data are lacking. Adapted from U. S. Dept. of Agr., Farmers' Bulletin 1510.

Virginia is located in an area of the United States where the disease known as anthracnose is a serious drawback to

the production of red clover (see Fig. 1). In this anthracnose-infested area the attacks of this disease are a much more important factor in clover production than winter-killing when the clover is seeded at the proper time. Much has been said about using clover seed which has been produced in cold climates. Red clover seed produced under such climates is not especially valuable in Virginia unless it possesses the ability to resist anthracnose. In Virginia the anthracnose disease is one of the most serious causes of clover failure—much more important than winter hardiness. It is not intended to minimize the importance of lime, fertilizers, proper seeding, proper preparation of the seedbed and inoculation in the production of red clover; but, if best results are to be secured, the right kind of seed is also necessary.

The importance of anthracnose in causing clover failure has been known for a long time by plant pathologists, and in 1905 the Tennessee Agricultural Experiment Station made selections of red clover plants resistant to the disease. These selections were the foundation stock of the Tennessee anthracnose-resistant red clover which is still being grown by some of the farmers in Tennessee. Unfortunately the supply of seed is very limited.

Symptoms of Anthracnose

Anthracnose of red clover in Virginia is caused by a fungus, the scientific name of which is *Colletotrichum trifolii*. The symptoms of the disease and the injury resulting from its presence are described in Farmers' Bulletin 1510 of the United States Department of Agriculture. The disease may attack any part of the plant from the time the plants are very young until they have reached their full development. However, the disease develops most abundantly during warm, moist weather and its greatest development is usually reached from July to early September.

On the young plants or seedlings the spots of anthracnose are usually seen on the leaf stems or at the base of the leaflets. The spots may be circular or elongated and at first appear as soft discolored areas which later become shriveled and dark brown, finally turning black and brittle. On the older plants the attacks of the disease are usually on the stems and its presence is shown by elongated, dark-colored sunken areas which have a distinct black border with a brownish or grayish center (Fig. 2). However, the presence of the disease is not limited to the stems but may be found on any part of the plant as in the case of the seedlings. The greatest damage from the disease is found when the crowns or taproots are attacked. In such

FIG. 2.—Anthracnose is present on the stem of red clover on the left as shown by the dark-colored spots. The stem on the right is free from the disease. (Photograph taken by Dr. S. A. Wingard.)

cases there is little likelihood of recovery (Figs. 3 and 4). If the portions of the plant above the crown are attacked, the plants may be weakened and development delayed but there is a chance for the plant to resist the disease and recover.

Where the attacks of anthracnose are severe the plants become black and brittle and the crop has the appearance of having been allowed to stand too long without being harvested. Frequently the anthracnose prevents much development of the plants and the blackened, dying crop appears to have reached its final development prematurely.

Fall as Compared With Spring Seeding

The experience of good farmers and the results secured from experiments conducted by this Experiment Station show that red clover seeded alone on specially prepared land in the late summer or fall gives much better results on the whole than it does when seeded

in the spring on small grains. The reasons most commonly given for the frequent failure of spring seedings of red clover are, shading by

FIG. 3.—A wonderful stand of anthracnose-resistant clover. Such stands will produce abundant feed and furnish much soil improvement. Compare with Fig. 4.

the nurse crop, destruction by the hot sun after the nurse crop is removed, and summer droughts; but not the use of the wrong kind of seed, which is a very important item. It is common knowledge that farmers wait until fall before deciding definitely whether the spring-seeded clover crop will be a success or a failure. Tests and observations show that one of the chief reasons for the death of spring-seeded clover during the following summer is anthracnose infection.

Frequently excellent stands of clover are secured from the spring seedings and during the cool growing season of the spring and early summer good growth is made. Later on during the summer the development of the plants is frequently less rapid and many of the plants die or take on an unhealthy appearance. Much of the injury is the result of anthracnose infection. The disease begins development to a marked degree usually early in July and continues to early September. During this period many plants may be killed and many others weakened but not destroyed. During the cool period of the fall the healthy as well as the weakened plants make comparatively rapid growth as the cool weather of the fall is favorable for the development of the clover but unfavorable for the development of the

anthracnose disease. During the winter months many of the plants weakened by anthracnose die and the stand in the spring is much inferior to the stand in the fall. In such cases the injury is likely to be attributed to cold rather than to the disease. If the plants are healthy and vigorous, there is not much chance for spring-seeded clover to winter-kill the following winter in this latitude.

Results of tests indicate that when red clover seed is used that is likely to be injured by anthracnose, and if its ability to resist the disease is unknown, the better practice is to seed in the fall rather than in the spring. Red clover, in common with many other crops, has greater ability to resist disease if conditions affecting growth, such as soil and climate, are favorable. The experience of good farmers shows that as a general rule spring seeding of red clover will give good results if the land will produce 40 or more bushels of corn per acre. If the land will produce much less than this amount of corn, the clover should be seeded in the fall or late summer.

When clover is seeded in the fall or late summer, if soil conditions are favorable (Fig. 5), a good crop is generally secured in the early

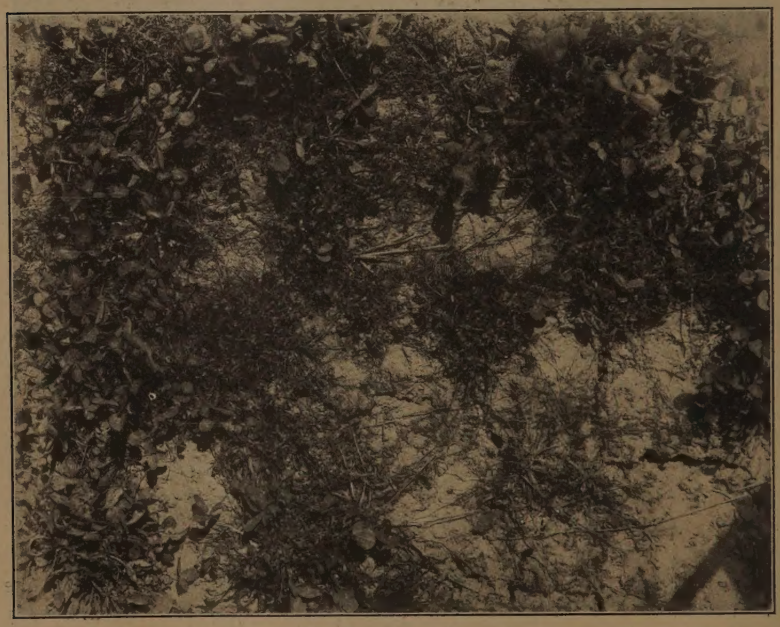

FIG. 4.—Italian red clover practically ruined by anthracnose. The entire plants are affected and many are dead. Such seed is worth but little to Virginia farmers. Compare with Fig. 3.

part of the following summer regardless of whether or not the clover is resistant to anthracnose. However, in case of very susceptible kinds great damage may be done to the first crop. The clover makes a good growth during the cool weather of the spring and early summer and the anthracnose develops but slowly under the cool weather conditions. The greatest damage by the anthracnose is seen after the first cutting is removed. As a general rule the less resistant sorts fail to show much recovery after the first cutting while the resistant

FIG. 5.—The surest way to secure a crop of clover is to seed it alone in the fall on a specially prepared seedbed. This method is safer than seeding on small grain in the spring.

kinds usually recover readily and give a good second crop. The failure to secure a second crop of clover is a serious drawback to sound agriculture (Figs. 6 and 7). It is this second crop which furnishes a good supply of hay or grazing, a large amount of organic matter to turn down for corn, much nitrogen from the air; and frequently the second crop is used for seed.

The results presented in Table 1 show the anthracnose infection and yields from red clover seed seeded at different times. The results cover only one year and are, therefore, not conclusive. They are given since they agree with results secured elsewhere in showing that frequently anthracnose infection is less and the yields larger from fall seedings than from spring seedings. There is abundant evidence to be

FIG. 6.—Anthracnose has practically prevented a second growth from being produced from this Italian red clover seed. Compare with Fig. 7.

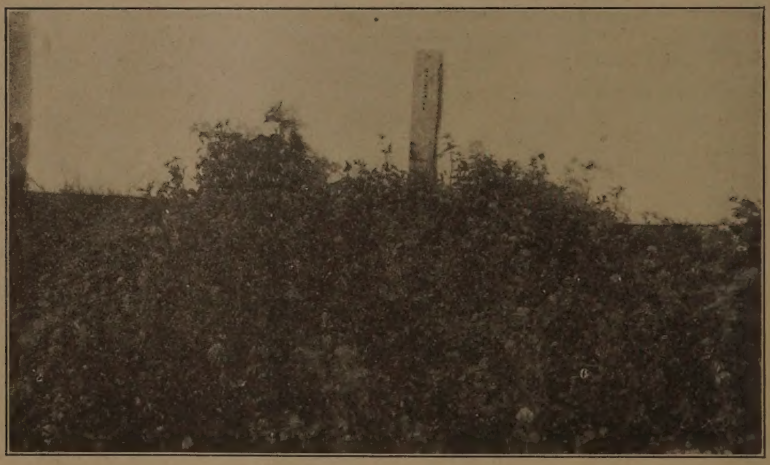

FIG. 7.—This anthracnose-resistant clover has produced an excellent second growth. Compare with Fig. 6.

secured from experimental results and from farmers which shows greater difference in yield in favor of late-summer seedings as compared with spring seedings than is shown in Table 1.

TABLE 1.—*Showing anthracnose infection in July, 1925, and yields of red clover hay in 1925 from seed from different sources seeded in the spring and in the fall of 1924.*

Source	Per cent of anthracnose infection		Yield per acre, tons	
	Spring seeding	Fall seeding	Spring seeding	Fall seeding
Michigan	7	20	1.61	2.30
Ohio	12	15	1.51	1.54
Maryland	20	20	1.11	1.61
Oregon	30	35	1.55	1.21
Chile	90	60	1.70	1.81
England	90	75	1.49	2.02
France	100	60	1.15	1.37
Hungary	100	70	1.14	.92
Italy	100	75	.87	.81

The clover seeded in the fall of 1924 showed practically no anthracnose infection that fall. Notes taken in August, 1924, showed the following results in reference to anthracnose infection of the sources of clover seeded in April, 1924: English, Michigan, Maryland, Ohio, and French clovers showed about the same resistance to anthracnose. There was some anthracnose present but the plants were vigorous and well established. About 5 to 10 per cent of the plants were dead. Chilean and Oregon clovers showed considerable loss from anthracnose. Hungarian and Italian clovers showed the greatest loss from anthracnose, and in many places in the plats about one-half of the plants were dead.

Resistance to Anthracnose of Red Clover Seed From Different Sources

In determining the resistance to anthracnose of red clover from different sources, generally the best indications of resistance are found after the first crop is harvested. In case of those kinds which are susceptible to the disease there is usually little if any recovery after the first cutting, due to the destruction of the plants by the disease. Regardless of the kind of seed used, in order to secure the largest amount of second crop, it is important to cut the first crop early, that is, when the first heads begin to turn brown. This practice will reduce the yield of the first cutting, but the difference will be more than made up in the second cutting, provided anthracnose-resistant seed is used. If almost all of the heads are allowed to turn

brown and become ripe before the first crop is harvested, the second crop is likely to be greatly injured. If the first crop is not cut early, the yield of the second crop may be greatly reduced even when anthracnose-resistant seed is used.

In the red clover tests harvested at the Charlotte County Experiment Station in 1923, 90 per cent of the plants from Ohio and from Idaho seed recovered after the first cutting, while only 10 to 25 per cent of plants from several imported lots recovered. The seed of the imported lots used in the tests was from Chile, France, Hungary, Northern Germany, Bohemia, and Italy. At Blacksburg the tests included seed grown in Tennessee, Wisconsin, Ohio, and Oregon, as well as in various European countries and in Chile. Anthracnose occurred on all the plats, but apparently did but little injury this season. The seed from Tennessee, Ohio, Wisconsin, and Hungary gave the largest yields.

In 1924, results were secured from seed grown in Tennessee, Ohio, Michigan, Idaho, and Minnesota, as well as from seed grown in various European countries and in Chile. The yields from the Ohio and Tennessee anthracnose-resistant seed were about the same. The clover from both of these sources recovered equally well after cutting the first crop. Michigan and Idaho-grown seed showed much resistance to anthracnose but the yields were less than from the Ohio and Tennessee seed. The Minnesota seed did not prove to be especially adapted to Virginia conditions. With the exception of the Chilean-grown seed, which gave a very small second cutting, none of the imported lots gave a second cutting (Table 3).

The 1925 results showed Ohio, Maryland, Virginia, and Michigan red clover to be the most resistant to anthracnose. Tennessee seed was not included in the test. The plants produced from seed grown in the foreign countries and in Oregon proved to be susceptible to anthracnose.

The results for 1926 were secured from seedings made in August, 1924. This seeding gave two cuttings each in 1925 and in 1926. The Ohio, Maryland, and Virginia plats made good recovery after the second cutting in 1926, while none of the other plats showed any recovery of consequence in that year. The observations in reference to anthracnose were practically the same as in 1925. No stands were secured from the seedings made in 1925 on account of the extremely dry season. Some of the sources of red clover seed were not included in all of the years on account of inability to secure seed.

In 1926 two cuttings were secured from foreign-grown seed, with exception of seed from Italy, as well as from domestic-grown seed

sown in August, 1924. Conclusions in regard to foreign-grown red clover seed are based upon observations and tests of several years, and are in a sense broad conclusions. In any one year these conclusions may be accepted or questioned, depending upon such factors as the character of the season and the seed. In some seasons the foreign-grown red clover seed may give good results and in other seasons the reverse. The results to be secured are uncertain. In case of some of the domestic-grown seed such as seed grown in Tennessee, Virginia, Maryland, and Ohio, the yields are much more certain and excellent results are generally secured.

The available results of red clover trials conducted in Virginia by this Experiment Station and at the Arlington Farm by the United States Department of Agriculture show that the sources of red clover most resistant to anthracnose are Tennessee disease-resistant, Virginia, Maryland, Ohio, and Michigan. The resistance of seed from the four first named sources to the disease has been more consistent than that from the last named source.

Yields of Hay from Red Clover Seed From Different Sources

The chief reason for planting red clover is to obtain high yields of feed either as pasturage or hay, and to improve the soil. The value

FIG. 8.—When clover fails, nature occupies the land with weeds. A good crop of clover would be much more profitable.

of red clover, both as feed and as a soil improver, is too well known to need discussion. It may be said, however, that the greater the yield of feed the greater is the amount of organic matter left in the form of stubble and roots for the improvement of the soil. The longer the life of the clover crop the greater are the returns from a single seeding. It is, therefore, to the advantage of the grower to purchase the best clover seed obtainable (Fig. 8).

FIG. 9.—A poor substitute for red clover. Italian-grown red clover seed was seeded on the right and English-grown on the left. Compare with Fig. 10.

The results shown in Tables 2 to 6, inclusive, show that there is a great difference in the amount of hay produced from red clover seed from different sources (Figs. 9 and 10). They show that the yields of hay from red clover seed from foreign countries are not as high as those from some of the seed grown in the United States and in some cases, as shown in Table 3, no second growth was produced. On the other hand, some of the seed from foreign countries is apparently better than that produced in some of the States in this country. Such results indicate that the grower must use care in purchasing red clover seed and make sure that it was produced in a section which produces seed that will yield well in Virginia (Fig. 11). It seems that the best red clover seed for the Virginia farmer to use is that seed which is produced under conditions similar to those existing in Virginia. Since anthracnose plays such a large part in red clover production in Virginia, so far as possible, the Virginia farmer should purchase red clover seed that has been produced in the anthracnose-

infested area of the United States. Under such conditions only types resistant to anthracnose can survive and produce seed.

The tests show that Tennessee-grown, Ohio-grown, and Michigan-grown red clover seed have given the highest yields of hay. The Maryland seed has shown up well and at the Arlington Experimental Farm in Virginia in tests conducted by the United States Department of Agriculture it has given excellent results. Virginia-grown seed has not been used to secure yields at Blacksburg, but results secured by the United States Department of Agriculture from tests conducted in Virginia show that it has yielded exceptionally well. Virginia-grown seed has given splendid results on the farms in this State, and it seems to be one of the best sources of red clover seed for Virginia. These results show that the best red clover seed for the Virginia farmers is that grown in Tennessee, Virginia, Maryland, Ohio, and Michigan.

It is not practicable at the present time for Virginia farmers to secure all of the red clover seed needed from Tennessee, Virginia, Maryland, Ohio, and Michigan. It is necessary that some red clover seed be bought from other sources. In case it becomes necessary to

FIG. 10.—With such crops of clover there need be but little worry in feeding livestock and building up the soil. Tennessee-grown red clover seed was seeded on the right and Michigan-grown on the left. Compare with Fig. 9.

use foreign-grown red clover seed the tests so far conducted indicate that seed from Chile, France, and the North European countries is the best of the foreign sources for Virginia conditions. The inability to secure red clover seed from the states whose seed has given best results

should not prevent the grower from using a legume. In this case the farmer has the choice of purchasing red clover seed from some other source or using some substitute, such as alfalfa, sweet clover, alsike clover, and mammoth clover.

As shown in Table 5, the seed from Ohio and Maryland which was planted in August, 1924, has produced plants with a much greater length of life than the other sources of seed planted at the same time. These two sources of seed also showed a fairly good recovery after the second cutting in 1926. Very good stands of red clover from all the sources were secured when the seedings were made. The decrease in stands were largely due to the presence of anthracnose.

FIG. 11.—The source of seed may determine whether the clover crop will be successful. A, Tennessee; B, Ohio; C, Germany; and D, Italy.

TABLE 2.—*Yields of hay at Blacksburg in 1923 from red clover seed from different sources, and stands at different dates. Seeded April 12, 1922.*

Source	Yields in tons per acre			Per cent stand	
	First cutting	Second cutting	Total	Sept. 1, 1922	May 1, 1923
Tennessee	1.69	.83	2.52	90	75
Ohio	1.79	.64	2.43	100	70
Wisconsin	1.69	.72	2.41	85	75
Hungary	1.59	.67	2.26	100	65
Austria	1.30	.56	1.86	100	70
France	1.34	.50	1.84	100	60
Chile	1.28	.48	1.76	90	51
Bohemia	1.19	.52	1.71	100	68
Germany	1.19	.44	1.63	100	75
Oregon	1.17	.39	1.56	100	65
Wales	1.09	.43	1.52	100	65
Idaho	.87	.46	1.33	95	35
Italy	.62	.26	.88	73	8

The greater length of life of those plants produced from adapted seed as compared with those produced from unadapted seed is an outstanding characteristic.

TABLE 3.—*Yields of hay at Blacksburg in 1924 from red clover seed from different sources, and stands at different dates. Seeded March 31, 1923.*

Source	Yields in tons per acre			Per cent stand	
	First cutting	Second cutting	Total	Nov. 2, 1923	Apr. 14, 1924
Tennessee	2.05	.62	2.67	97	59
Ohio	2.08	.52	2.60	84	58
Michigan	1.63	.34	1.97	84	32
Chile	1.58	.07	1.65	75	42
Idaho	1.19	.28	1.47	68	24
Germany	1.25	--	1.25	48	28
Bohemia	1.23	--	1.23	57	25
Minnesota	1.07	.10	1.17	49	19
Austria	1.05	--	1.05	62	13
Russia	.99	--	.99	62	39
England	.93	--	.93	56	16
Hungary	.80	--	.80	57	18
Poland	.62	--	.62	74	14
Italy	.36	--	.36	56	11

TABLE 4.—*Yields of hay at Blacksburg in 1925 from red clover seed from different sources, and stands at different dates. Seeded August 6, 1924.*

Source	Yields in tons per acre			Per cent stand	
	First cutting	Second cutting	Total	Oct. 2, 1924	Mar. 23, 1925
Michigan	1.93	.37	2.30	68	78
England	1.70	.32	2.02	67	69
Chile	1.51	.30	1.81	76	67
Maryland	1.26	.35	1.61	68	74
Ohio	1.30	.24	1.54	73	76
France	1.07	.30	1.37	43	52
Oregon	1.04	.17	1.21	63	65
Hungary	.83	.09	.92	68	68
Italy	.65	.16	.81	76	33

TABLE 5.—*Yields of hay at Blacksburg in 1926 from red clover seed from different sources, and stands at different dates. Seeded August 6, 1924.*

Source	Yields in tons per acre			Per cent stand	
	First cutting	Second cutting	Total	Mar. 23, 1925	June 5, 1926
Ohio	1.20	.67	1.87	76	54
Maryland	1.05	.71	1.76	74	74
Chile	.79	.65	1.44	67	18
Michigan	.87	.51	1.38	78	25
France	.69	.43	1.12	52	26
Oregon	.54	.36	.90	65	25
Hungary	.36	.24	.60	68	20
England	.22	.18	.40	69	7
Italy	0	0	0	33	0

TABLE 6.—*Total yields of hay at Blacksburg from red clover seed from different sources.*

Source	Yields in tons per acre			
	1923	1924	1925	1926
Tennessee	2.52	2.67	---	---
Ohio	2.43	2.60	1.54	1.87
Maryland	---	---	1.61	1.76
Michigan	---	1.97	2.30	1.38
Wisconsin	2.41	---	---	---
Idaho	1.33	1.49	---	---
Minnesota	---	1.17	---	---
Oregon	1.56	---	1.21	.90
Chile	1.76	1.65	1.81	1.44
France	1.84	---	1.37	1.12
Germany	1.63	1.25	---	---
Austria	1.86	1.05	---	---
Hungary	2.26	.80	.92	.60
Bohemia	1.71	1.23	---	---
Poland	---	.62	---	---
England	---	.93	2.02	.40
Russia	---	.99	---	---
Wales	1.52	---	---	---
Italy	.88	.36	.81	0

Distinction Between Seed Grown in the United States and Other Countries

There is no way of distinguishing seed produced in the United States from that which is imported except by the stain which is applied according to law. A recent Federal law requires all imported red clover seed to be colored before it can be unloaded in the United States. In case of the red clover seed from Italy, at least 10 per cent of the seed of each container must be stained red; that from Canada at least 1 per cent iridescent violet; and that from all other countries at least 1 per cent green.

In case of the plants produced from domestic- and foreign-grown seed of red clover, a difference exists in the hairiness of the stems (Fig. 12). The distinction is not pronounced on the young plants but it can be readily seen in the older plants which have produced stalks. The domestic and Canadian seed produce plants which usually have very hairy stalks and the hairs tend to stand at right angles to the stem. The plants produced from seed grown in foreign countries except Canada are either free from hairs, or smooth, or they have a few hairs which lie close against the stem. Figure 12 shows the difference in hairiness of domestic and foreign red clovers.

FIG. 12.—Earmarks of red clover. The two stems on the right were produced from United States-grown red clover seed and the two on the left from foreign-grown seed. (Photograph taken by Dr. S. A. Wingard.)

Production of Red Clover Seed in Virginia

The exact figures are not available, but about 450,000 acres of red clover are seeded in Virginia each year. It requires approximately 75,000 bushels of red clover seed to seed this acreage. There are not over 7,500 bushels of red clover seed produced in Virginia each year. Therefore, the farmers of the State purchase from outside sources large quantities of red clover seed annually. Much of the seed bought and seeded is unsuited to Virginia conditions. The results of trials and the experience of farmers show that Virginia-grown red clover seed is well suited for seeding in Virginia. The farmers of the State can well afford to increase the production of red clover seed because the present supply is limited, the price is high, and the returns to the purchaser as well as to the seller are satisfactory.

The production of red clover seed was much greater in Virginia years ago than it is at the present time. It has been stated that only a few years ago about 3,500 bushels of red clover seed were shipped

from the "Northern Neck" of Virginia yearly. One of the chief reasons for the decrease in production of red clover seed in Virginia was the poor appearance of the seed, and the high weed seed content in comparison with seed obtainable in commercial quantity from many other sources. It appears that more attention was paid to the appearance of the seed than to its ability to produce good crops. During recent years the difference in the power of red clover seed to produce high yields has been learned and the result should encourage increased production of red clover seed in Virginia.

Red clover seed which has been produced in Virginia for a number of years should be resistant to anthracnose. Plants adapt themselves to adverse conditions through the process of natural selection. Thus when red clover is produced in Virginia, when the seasons are favorable for the development of anthracnose, the susceptible plants are killed by the disease while the more resistant ones remain and produce seed. In this way a type of red clover is obtained which has the ability to withstand the attacks of the disease. It is known that certain farmers in Virginia have grown their own red clover seed for ten to fifteen years and some even longer without securing seed from outside sources. Since the development of anthracnose is largely dependent upon weather conditions, seed that has been grown for several years on the same farm should be more resistant to the disease than that which has been grown for one or two years and probably has not been grown during seasons favorable to anthracnose.

Practically all of the red clover seed produced in Virginia is taken from the second crop. The first crop is used for hay as it usually does not produce much seed. The first crop, if it is a good one, will more than pay for its own cost of production and the cost of production of the seed crop. Therefore, in the production of red clover seed from the second crop there is little chance for loss. It is generally stated that when many of the clover heads have twenty-five to thirty seeds per head and the stand is good the crop is worth harvesting for seed. Under such conditions the yields of seed will be from one to two bushels per acre. The average yield of red clover seed for the United States is 100 pounds. The yield in Virginia frequently runs as high as two to three bushels, but sometimes less than a bushel. At the present price of red clover seed ($20 to $25 per bushel) a yield of one bushel per acre is profitable.

Since red clover seed in Virginia is produced from the second crop, and since it is this crop that is attacked most severely by anthracnose, seed which has been produced for a number of years in Virginia should be resistant to the disease. This seed should be an

excellent source from which to secure seed stocks for the production of red clover seed in Virginia.

One of the serious drawbacks to the production of red clover seed in Vrginia is the presence of weeds, especially buckhorn *(Plantago lanceolata)* also known as narrow-leaf plantain, ribwort, ripple, and rib-grass.

In the production of clover seed steps should be taken to hold this weed in check as far as possible. It would be much better, so far as practicable, to produce red clover seed free from buckhorn than to remove it from the clover seed after they are hulled. The removal of buckhorn seed from red clover seed is troublesome and expensive. In the production of red clover seed it has been found that when a good stand of clover is secured the clover tends to hold the buckhorn in check. It is also believed that seeding the clover crop in the late summer rather than in the spring will aid in decreasing the amount of buckhorn. So far as practicable clean land should be selected for producing the red clover seed crop.

Removal of Buckhorn from Red Clover Seed

It is difficult to remove buckhorn from red clover seed because the two kinds of seed are about the same size. However, there are cleaning machines on the market which will remove practically all of the large and plump buckhorn seeds. The cleaning machines will not remove all of the small buckhorn seeds and a special method must be used for their removal. The principle of this method was worked out by the United States Department of Agriculture some years ago. It was found that when buckhorn seeds were wetted a mucilaginous coat was formed around each seed. When dry sawdust was mixed with clover seed containing buckhorn which had been made wet the sawdust adhered to the buckhorn seeds, forming buckhorn-sawdust masses while the sawdust did not adhere to the red clover seed. When the sawdust mixture was placed on the proper sieves the buckhorn-sawdust masses being larger than the clover seed remained on top of the sieves and the clover seed passed through. There is a small loss of clover seed as some of them adhere to the wet buckhorn seed.

In work done by the Virginia Agricultural Experiment Station in the removal of buckhorn from red clover seed it was found that frequently much of the buckhorn seed could be removed by the use of the proper kinds of sieves in a good type of cleaning machine such as is frequently found on farms in this State. The sawdust process

was used to remove the remaining buckhorn seed. It was found by the use of these methods that the buckhorn could be reduced from 75 per cent to less than one-half of one per cent with practically no loss of clover seed. The clover seed containing the buckhorn was first run over the proper sieves in the cleaning machine, and then the sawdust process was used. It was found that sawdust of medium fineness gave the best results. It is important to have sawdust that is well air-dried and to remove the dust and the coarse particles and to use that of medium fineness. It was also found that wetting the clover and buckhorn seed before adding sawdust caused many of the clover seed to adhere to the buckhorn. The best results were secured by mixing two parts by volume of dry sawdust with one part of clover and buckhorn seed and wetting thoroughly with water. The wet mixture was allowed to stand for five or six minutes and drain and then six parts of dry sawdust were added and mixed thoroughly, or enough sawdust to bring the mixture from wetness to dampness. The damp mixture was run at once through the cleaning machine over the proper sieves. The buckhorn-sawdust masses passed over the sieve while the clover seed passed through the sieve. Some of the clover seed adhere to the buckhorn-sawdust masses but most of them can be recovered by gently rubbing the masses to remove the clover seed and passing them through the cleaning machine a second time. The mixing of some sawdust with the seed before wetting as compared with wetting the seed and mixing in the sawdust later not only allowed a better separation of weed and clover seeds but prevented the clover seed from swelling as much.

Substitutes for Red Clover

Because of the present high price of red clover seed and the difficulty in securing adapted seed, many farmers are using substitutes for red clover. It is a poor practice and false economy not to grow legumes in the rotation. The legumes most commonly used to replace red clover are alfalfa, sweet clover, alsike clover, and mammoth clover. Sometimes soybeans or cowpeas are used as substitutes for red clover but these crops when harvested do not improve the soil as much as red clover.

Several legumes have proved to be satisfactory substitutes for red clover under particular conditions which are met with in this State. On land capable of producing 50 bushels of corn or more to the acre, if such land has been limed during the last 5 years, a mixture consisting of 15 pounds of alfalfa seed and 4 pounds of alsike clover

seed per acre makes a very satisfactory substitute for red clover.

On land producing less than 50 bushels of corn per acre, if it has been limed during the last 5 years, two substitutes for red clover are suggested, either of which will usually prove satisfactory: (1) 25 pounds of unhulled sweet clover seed per acre (if scarified seed is used the rate of seeding should be 15 pounds per acre). (2) 20 pounds of unhulled sweet clover seed per acre (or 12 pounds of scarified seed) and 4 pounds of alsike clover seed per acre.

Recent tests indicate that unhulled sweet clover seed will give better stands and higher and more profitable yields than scarified seed. The unhulled seed should be used in preference to scarified seed even though the acre cost of seeding is higher. The greater amount of hay secured and the better assurance of securing a stand when unhulled seed is used, as compared with scarified, more than offsets the difference in cost of seeding.

On land that has not been limed during the last five years the following substitutes for red clover are satisfactory: (1) 4 pounds of mammoth or sapling clover seed per acre and 6 pounds of alsike clover seed per acre. (2) 8 pounds of alsike clover seed per acre.